MACROBRACHIUM: TIGER OF THE NIGHT WATERS

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Abstract: The giant shrimp (*Macrobrachium* sp.), a nocturnal crustacean of up to 15 cm in length is characterized as a detritivore but could function as an important predator in neotropical streams. In situ enclosure experiments revealed that giant shrimp consistently consumed 5 of 5 tadpoles that were available, and 2 – 3 of 5 tetra fish. Under at least some circumstances, giant shrimp can clearly function as predators of stream-dwelling vertebrates. The higher susceptibility to predation of tadpoles vs tetra may explain why *Bufo* sp. tadpoles do not co-occur with giant shrimp in the same local pools. Tetra activity was significantly reduced at night, which could be an adaptation to minimize predation risk from the nocturnal shrimp. However, nocturnal activity of tetra within a sample of 12 isolated pools was unrelated to shrimp abundance within the pool. Nonetheless, our results provide preliminary evidence that predation by giant shrimp may structure local activity patterns and landscape distributions of aquatic vertebrates on the Osa Peninsula.

Key Words: Astyanax fasciatus, *giant shrimp, Palaemonidae, predator-prey interaction*

INTRODUCTION

Biotic interactions can be key determinants of community structure in streams (Covich et al. 1999). In particular, large benthic invertebrate predators can control the presence, abundance, and even size of both vertebrate and invertebrate prey species (Covich et al. 1999). Although known primarily as a detritivore (Pennak 1978, Benstead et al. 1999), the adult giant shrimp (Palaemonidae: *Macrobrachium* sp.), a nocturnal crustacean, may also be an important predator in neotropical streams. In preliminary experiments conducted at Corcovado National Park, Costa Rica, we observed predatory behavior in giant shrimp. Shrimp preyed upon tetra, a small fish co-occurring with giant shrimp in low and mid-streams, and tadpoles (*Bufo* sp.), which were found in the high-order Rio Claro where adult giant shrimp are absent. These observations suggested that basic natural history information on the giant shrimp may be incomplete in that it could be functioning as a predator.

We hypothesized that predation by giant shrimp affects local abundance, activity and landscape-scale distribution of potential prey species in tropical streams. If so, tetra might limit their nocturnal activity to reduce predation risk, especially in pools with high shrimp abundance. We also hypothesized that tadpoles are excluded from lower-order streams by predation from giant shrimp, which implies that tadpoles are more susceptible to predation by shrimp than tetra.

METHODS

To evaluate the effect of giant shrimp on the diel pattern of activity of tetra we conducted paired day and night surveys of 10 pools within a 0.5 km stretch of the low-order tropical stream, Quebradas Cameronal, located south of the Sirena Station. We controlled for pool volume by selecting similarly sized pools based on visual estimation (mean volume ± 1 SD = 1.77 ± 0.7 m^3). Within each pool, abundance of tetra was estimated by 1 min visual counts and abundance of giant shrimp (length > 5 cm) was estimated by 4 min visual counts. All counts were preceded by a 2 min habituation period during which observers remained motionless at the edge of

the pool. To evaluate diel activity patterns in tetra, we conducted a paired t-test of fish abundance in focal pools for day and night surveys. We then used regression analysis to examine the relationship between giant shrimp abundance in focal pools and an index of nocturnal activity of tetra defined as the residuals from a best-fit linear regression of apparent tetra abundance during night vs day within the same pools. Tetra abundance measurements were log-transformed (base 10) to meet the assumptions of normality.

On 5 – 6 February 2000, we tested for giant shrimp predation on tetra and tadpoles with a controlled in-situ experiment in the Quebradas Cameronal. Experimental units were 6 liter tubular enclosures constructed of metal screening (mesh size = 4 cm). A single giant shrimp was placed in each enclosure. Mean length and mass of experimental shrimp (± 1 SD) was 12.1 ± 1.7 cm and 30.4 ± 9.4 g, respectively. We measured shrimp predation within three replicates of each of the following three treatments: (1) addition of 5 tadpoles, (2) addition of 5 tetra, and (3) the addition of 5 tadpoles and 5 tetra. All experimental tadpoles were collected in the Rio Claro (mean snout-vent length ± 1 SD = 0.54 ± 0.09 cm; mean mass ± 1 SD = 0.91 ± 0.12 g). All experimental tetra were collected in the Quebradas Cameronal (mean length ± 1 SD = 4.91 ± 1.58 cm; mean mass ± 1 SD = 2.7 ± 1.44 g). Enclosures remained in the stream from 16:00 until 08:00 the following morning, at which time we counted the number of each remaining prey type in each enclosure. We used contingency analyses to test for the effect of species (tadpole vs. tetra) on predation frequency and the effect of the presence of the other prey species (tadpole or tetra) on predation frequency. These analyses assumed each predation event to be independent, although this condition was not strictly satisfied by our experimental design (i.e., multiple prey per shrimp).

RESULTS

Tetra were more active during the day than at night (paired-t = 2.04 , df = 11 , p = 0.07; Fig. 1), but there was no relationship between the abundance of giant shrimp in focal pools and tetra nocturnality in those pools (r = -0.03, df = 1, p = 0.93; Fig. 2).

Shrimp preyed upon both tadpoles and tetras, but tadpoles were preyed upon at higher frequencies (G = 15.69, df = 1, p < 0.001; Fig. 3). There was no effect of the presence of the other prey species on the predation frequency of either tadpoles or tetra (G = 1.67, df = 1, p = 0.20 and G = 0.00, df = 1, p = 1.0, respectively).

DISCUSSION

Tetra activity in focal pools decreased during the night (Fig. 1); however, there was no evidence that tetra were adjusting diel activity patterns in relation to giant shrimp abundance in those pools (Fig. 2). Therefore, if low activity of tetra at night is the result of nocturnal predation risks from giant shrimp than this behavior is fixed within the tetra population, rather than a plastic response to local shrimp abundance. Experimental additions and/or removals of shrimp from stream pools could be used in future studies to further evaluate the plasticity of diel activity patterns in tetra.

Of course, low nocturnal activity could have an explanation that is independent of the shrimp. For example, if tetras are visual predators, like most fish, then they may be diurnal because they have better foraging success when they can see better. Controlled trials of tetra foraging efficiency under high and low light conditions and in the presence and absence of giant shrimp could clarify the ecological basis of tetra activity schedules.

Our enclosure experiments suggested that predation by giant shrimp could affect the

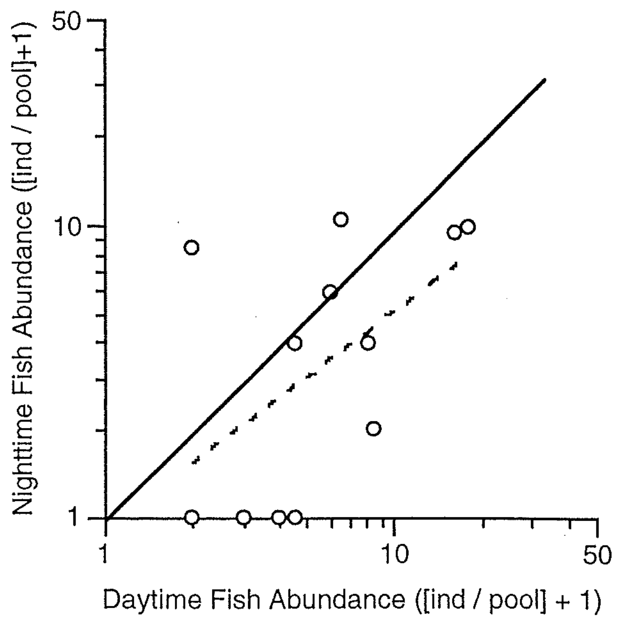

Figure 1. The relationship between daytime and nighttime abundance of tetra (ind/pool) in 10 pools in the Quebradas Cameronal, Corcovado N.P., Costa Rica. Solid line is the 1:1 regression line, dashed line is the best-fit regression line.

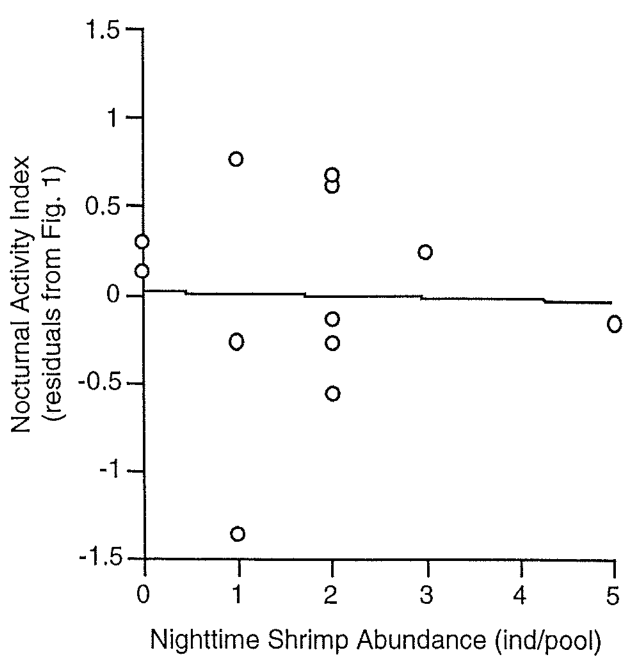

Figure 2. The relationship between nighttime giant shrimp abundance (ind/pool) and nocturnal activity index of tetra (residuals from Fig. 1) in 10 pools in the Quebradas Cameronal, Corcovado N.P., Costa Rica.

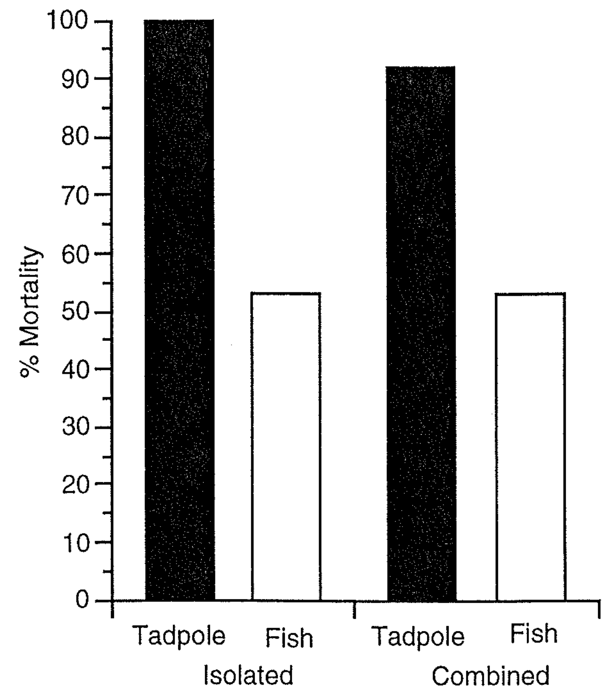

Figure 3. Percent mortality of fish and tadpoles in enclosure experiments with giant shrimp.

community structure of tropical streams. While we observed giant shrimp preying on both tadpoles and tetra in this experiment, tadpoles appeared to be more susceptible to predation from giant shrimp than tetra, suggesting that tadpoles are preferred prey and/or that they lack effective shrimp-predation avoidance mechanisms. Therefore, the lack of overlap between shrimp and tadpole distributions may be a result of predator-mediated exclusion of tadpoles from mid and low-order streams. Shrimp exclosures could be used to evaluate tadpole survivorship in these streams independent of shrimp predation. Additionally, analysis of shrimp stomach contents would indicate the extent of predation on tetra and tadpoles under natural conditions.

It is important to acknowledge that the conditions in experimental enclosures could have disrupted the predator-avoidance mechanisms of tadpoles (e.g., camouflage or microhabitat selection) more than tetra. If tetra

use speed or maneuverability to evade shrimp while tadpoles rely on being cryptic, than the enclosure environment may have provided an artificial handicap to the tadpoles. Tadpoles may also have been negatively affected by abiotic conditions at the site of the experiment (e.g., temperature, light regime) which differed from conditions in the Rio Claro. These effects could be evaluated by repeating the enclosure experiments in the Rio Claro. An observational study of shrimp, fish and tadpole interactions in a controlled environment could offer further insights regarding prey preference of giant shrimp and differences between tadpole and fish in their predator avoidance behaviors.

By documenting predation on two stream vertebrate species, this study expands our understand of the natural history of *Macrobrachium* sp. on the Osa Peninsula. Our data provide preliminary evidence that predation by *Macrobrachium* sp. could have local and watershed affects on the activity and distribution of potential prey species in tropical rivers. Through their direct affects on tetra activity and tadpole distribution, giant shrimp could indirectly influence other attributes of streams, such as insect abundance and primary productivity. Changes in the giant shrimp abundance, such as those caused by increased impoundment of tropical streams (Benstead et al. 1999), may therefore affect multiple trophic levels and numerous riverine processes.

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